Summary of Joint GATE-M Issues
February 2003

Intelligence in Manufacturing

Intelligence in Manufacturing represents an enabling, crosscutting technology area that is potentially transformative in terms of how manufacturing might be conducted in the future. The area is gaining interest across multiple industry sectors for a variety of reasons, and all of the GATE-M agencies have programs currently in place that directly address this area or are directly relevant. This is an area where GATE-M could immediately begin to make an impact through joint address across the agencies.

Significant opportunity exists for manufacturing R&D to make a difference in the area of Intelligence in Manufacturing. For example, this area could have a big potential impact on supply chain cost, quality, and reliability. Additionally, the manufacturing community is just beginning to tap the capabilities for manufacturing that are afforded by intelligent, open architecture control. There could also be significant opportunities for agencies with product-oriented missions to apply technology developed elsewhere (i.e., at another GATE-M agency) to specific manufacturing problems in their product-specific domains.

This issue is intended to include all those technologies relevant to the development and incorporation of intelligent systems and controls into manufacturing operations. By intelligent control, researchers usually mean model-based sensing or model-based control, and the general focus of the research community is now on intelligent systems, rather than on limited individual aspects of sensing or control, including distributed control among multiple autonomous agents or machines.

Topics of interest to the GATE-M agencies include, but are not limited to, the following:

- sensing and control that allows manufacturing systems to be non-linear, adaptive, goal-oriented, knowledge-based, autonomous, capable of learning, able to deal with uncertainty, and able to deal with symbolic reasoning;
- the provision of a comprehensive manufacturing model to assist in the reduction of manufacturing design changes, development cycle times, and costs; and
- intelligent advisors to provide knowledge-based optimization of product and process designs.

Nano- / Micro-Scale Systems and Technologies

Nano- / Micro-Scale Systems and Technologies represents an area that is not highly mature, but where good opportunity exists for manufacturing R&D to make a difference. This relative lack of maturity means that this as an issue for GATE-M address in a longer-term basis. This is a very important, emerging science and technology area that promises significant and broad impact to the future of U.S. manufacturing, as well as the U.S. economy and society on a large scale. This is an area with many manufacturing and

systems issues, where GATE-M could likely find several ways to pull the missions of its participating agencies together. A number of electrical and mechanical application areas exist or are being investigated, and assembly areas and measuring techniques and tools could be fertile topics to pursue. GATE-M focus should not stray into science, but stay focused on manufacturing technology. GATE-M activities in this area need to be coordinated with the activities and committees of the National Nanotechnology Initiative, which is a multi-agency federal initiative being overseen by the White House Office of Science and Technology Policy. More information about this initiative can be obtained at www.nano.gov.

Nanotechnology is generally considered to include research and technology development at the atomic, molecular or macromolecular levels, in the length scale of approximately 1 - 100 nanometer range, to provide a fundamental understanding of phenomena and materials at the nanoscale and to create and use structures, devices and systems that have novel properties and functions because of their small and/or intermediate size. Microtechnology generally includes systems and technologies relevant to microelectronics and microelectromechanical systems (MEMS).

Topics of interest to the GATE-M agencies include, but are not limited to, the following:

- enabling metrology for nanoelectronics
- measurement technologies for determining the properties and dynamics of magnetic nanostructures and the necessary models to explain the measurements
- measurements traceable to fundamental units that support and enable future application of nanotechnology through measurement methods, standards, and data
- the measurement science infrastructure to enable the development and application of nanostructured materials including nanoscale thin films, nanotubes, nanoparticles, and nanocomposites
- the measurement science to study and manipulate individual biomolecules and biosurface interactions enabling new nanodevices, nanosystems, and applications
- the science and technology of nanodevices dependent on quantum interactions in areas related to fundamental standards, advanced measurement methods, and quantum computation; development of the ability to model MEMS devices
- development of common/flexible, repeatable manufacturing and assembly processes for MEMS devices
- address of MEMS packaging issues related to their intended use including form, fit, and function issues
- address of environmental issues that include sensitivity to thermal and mechanical shock, external temperature variance, and vibration
- development of in situ testing during the manufacturing process and final acceptance testing
- development of the ability to fabricate thin film networks with very high circuit density and development of assembly processes compatible with the smaller interconnect pitch for microelectronics and Microsystems
- development of the ability to embed and/or deposit passive components on thin film networks, thick film networks, and low temperature co-fired ceramic networks;

development of assembly technologies for integrated packaging that includes semiconductors, optoelectronics, and MEMS

- development of the structural applications of nanotechnology and the low cost manufacture of nano-materials
- the manufacture of devices, parts and systems with critical dimensions that are less than one micrometer, including lithography and other methods, especially for the manufacture of 3-D objects
- improvement of biorefinery processing, conversion, fuel, product & power technologies
- improvement of biomass harvest, transport, storage technologies and infrastructure.